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INTRODUCTION

This study has been undertaken for the purpose of providing a detailed account of the external morphology of a Phaneropterine insect, of the family Tettigoniidae, order Orthoptera. Although a few isolated accounts of portions of such insects are available, no complete and comprehensive study of the morphology of an insect belonging to the subfamily Phaneropterinae has been made.

It is hoped that the information, resulting from the study of the external morphology of this insect, will enable the student of phylogeny to derive a clearer understanding of the phylogenetic position of the group; and likewise that the taxonomist will have a better basis for determining the significant structures of classification.

It might also be mentioned that although the singing mechanism of katydids in general has long excited man's interest, no comprehensive work has been devoted to the insects complete morphology. It is hoped that this study will fill this gap by providing a morphological basis for future studies and observations.

The members of the subfamily Phaneropterinae are commonly known as the "false katydids", in contradistinction to the closely allied subfamily, Pseudophyllinae, which are designated as the "true katydids". One of the characteristics of the Phaneropterinae which distinguish them from the Pseudophyllinae, is that the hind wings are longer than the tegmina, whereas in the Pseudophyllinae the hind wings are shorter than the tegmina. Although the members of the false katydids, or Phaneropterinae, produce a definite call, their sound hardly resembles the familiar "katy did, she did, she didn't", and it should be noted that it was the song of one of the true katydids, or Pseudophyllinae, which gave rise to the common name for the group.

The species, Amblycorypha oblongifolia (DeGeer), was chosen for study, since it is a typical representative of the subfamily Phaneropterinae. Its wide range makes it readily available for study. According to Blatchley (1920) the known range of this species is "from New England and Montreal west to southwestern Ontario, Michigan, Minnesota and Colorado, and south and southwest to Maryland, North Carolina, Alabama, Louisiana and Texas". Thus it might easily be made available for class study in morphology, and in this guise it should be noted that its size, and the primitive structure of many of its parts would give the beginning student in morphology a sound basis for understanding the more specialized structures found in the members of higher Pterygotan orders.

The members of the genus Amblycorypha Stal, are commonly known as the "round-headed katydids" and A. oblongifolia is specifically known as the Oblong-winged Katydid. The following description of the species is taken from Blatchley.

"Size large for the genus; form robust. General color a bright pea-green, the shrilling organ of male brownish, with a heavy green cross-vein; abdomen and usually the fore and middle femora, yellowish or brownish green; hind femora often brownish-yellow. Disk of pronotum with sides distinctly divergent on basal two-thirds, subparallel with lateral carinae less distinct on apical third; humeral sinus well impressed; hind margin of lateral lobes broadly rounded. Tegmina elongate - elliptical, about 3.3 times as long as wide. Wings in repose surpassing tegmina six or more mm. Hind femora very slender, usually scarcely reaching tip of tegmina, female, distinctly shorter, male, their inner lower carina armed with six to twelve rather strong teeth.

Length of body, ♂, 21-23, of ♀, 22-25; of pronotum, ♂, 6-6.5, ♀, 7; of tegmina ♂ 36-36, ♀ 35-37; of posterior femora, ♂ and ♀, 30-31; of ovipositor, 11.5-13 mm. Width of tegmina, 11-12 mm.

THE HEAD

The head of A. oblongifolia is of the hypognathous type. Viewed from the front the head capsule and mouthparts are elongate-oval in outline (Fig. 1), and under alcohol the surface appears smoothly polished.

Head Capsule: The frons (fr) is a conspicuous area on the anterior portion of the epicranium.* Its limits, however, are not very clearly defined. When viewed exteriorly it appears to merge with the clypeus (clp) beneath it. Internally, however, there is a slight ridge (shown in Fig. 1 by a dotted line) extending between the anterior tentorial pits (atp) demarking its lower limits. The upper limits of the frons are demarked by the lower, mesal margins of the eyes, the basal and mesal margins of the antennal sclerites (asc) and the anterior margin of the fastigium (fst). The small, dotted area (ma) in the upper portion of the frons represents a conspicuous muscle attachment. Latterally the frons merges with the genae (ge) on each side of the head.

The genae are demarked ventrally by the subgenal sutures (sgs), dorsally by the temporal sutures (ts), and posteriorly by the post genal sutures (pgs), while the posterior margin of the eyes and the frons demark the anterior limits. Those portions of the genal areas behind the eyes

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* The term "epicranium" is here used to designate the paired areas of the head and the frons, but not including the clypeus.

and immediately beneath the temporal sutures, are sometimes designated as the tempora (te). Beneath the subgenal sutures are the subgenae (sge), variously called the basimandibulare and trochantin of the mandible. The postgenae (pge) lie behind the genae, from which they are separated by the postgenal sutures, while the post occipital sutures (pos) demark their posterior limits.

The dorsal portion of the head capsule is the vertex (xx), a flattened, anterior projection of which is set off as the fastigium (fst). No coronal suture is present to divide the vertex into two areas as is frequently the case in lower Pterygota. Likewise there is no occipital suture present which usually divides off the posterior region of the vertex into an occipital area, and such an area can only roughly be defined as the posterior region of the vertex.

When the head is removed and viewed from the rear (Fig. 2) a large opening called the occipital foramen (ocf) is plainly visible. Surrounding this opening laterally and dorsally is a narrow sclerite, the post occiput (poc), to the posterior margin of which the cervical membrane (cm) is attached. This sclerite is separated from the remainder of the epicranium by the post occipital suture (pos), and is shown in Fig. 2 in internal view since it is bent back upon the head capsule. A small portion of the posterior margin of the post-occiput is produced on each side into a small, cup-like process, the occipital condyle (occ), to which is articulated the cervical sclerite (cos), as shown in Fig. 6.

Tentorial Pits: Lying at the mesal extremity of each subgenal suture are the slit-like invaginations called the anterior tentorial pits (atp), sometimes termed the frontal pits; while lying at the back of the head, between the post-occiput and the postgenae at the ventral ends of the post-occipital sutures, are the prominent, elongated invaginations, the posterior tentorial pits (ptp), sometimes called the gular pits. Since there is no definite gular region in this form, however, the term "posterior tentorial pit" is preferable to "gular pit", and for sake of uniformity the term "anterior tentorial pit" is preferable, in this case, to "frontal pit".

Eyes: The compound eyes (e) are conspicuous elongate-oval structures, projecting from the upper, lateral portions of the head capsule. The number of facets in each compound eye approximates fifteen hundred. Ocelli are lacking.

Antennae: The antennae, located next to the lower, mesal margin of the eyes, are filiform in structure. They measure about 40 mm. in length and average between 160-170 segments. The basal segment of the antenna, or scape (scp) is roughly cylindrical and about twice as long as it is wide. Laterally its base is extended into a finger-like pivoting process (ap), while mesally its base is rounded into a ball shaped structure (bsc). The second segment of the antenna, or pedicel (pdc) is separated from the scape by a narrow circular membrane, within which it hinges. The pedicel is closely joined to the succeeding postpedicel (ppd), which represents the first segment of the flagellum of the antenna. (Figs. 1 & 3).

The base of the antenna is surrounded by an annular portion of the integement, known as the Antennal sclerite (asc). It bears a projection near the base of the antenna termed the antennifer (af). Fig. 1 shows the antennal articulating area (aar), left by the removal of the left antenna, to be relatively small one. The remainder of the membranous area within the antennal sclerite serves as an antennal socket (aso) for the swivel action of the ball of the scape (bsc), while the antennifer serves as a pivotal structure for the pivoting action of the antennal pivot (ap). This combination gives the insect considerable freedom of its antennae for forward, backward and rotating movements.

Clypeus and Labrum: The clypeus (clp) is a trapezoid-shaped sclerite, hanging by its longer base from the epicranium. Two narrow projections of its upper base merge laterally with the subgenae. As was mentioned above, there is no epistomal suture extending between the anterior tentorial pits to demark the clypeus from the frons.

The labrum (lr), attached to the lower base of the clypeus, is horse shaped in outline. No suture between the clypeus and labrum is present. The boundary between the clypeus and labrum is demarked on the oral, or pharyngeal, surface the tormae (to) to be described below.

Epipharynx: The epipharynx is a median lobe present on the posterior, or oral surface of the labrum and clypeus. (Fig. 5). It may be divided into a preepipharynx (pre) and a postepipharynx (poe) found on the oral surfaces of the labrum and clypeus respectively. In the lateral angles between the clypeus and the labrum are present thickenings, or ridges, which are termed tormae (to). These thickenings continue, somewhat less strongly, into the epipharyngeal region, and thus serve to demark the preepipharynx from the postepipharynx, as well as to demark the labrum from the clypeus.

Mandible: Fig. 4 represents a dorso-posterior view of the insect's dextral (right) mandible. The endognath (eg) is a basal, internal shelf projecting inward and extending around the triangular, basal portion of the mandible. Each of the sides of the triangle represents the base of one of the three surfaces of the mandible. There is an outer, or lateral surface, and an anterior and posterior surface. The edges of the latter two surfaces meet mesally to form the gnathal edge of the mandible. The gnathal edge is divided into a distal, or apical, incisor region (in), used for tearing the food apart; an intermediate grinding region, or mola (m); and a basal region containing stiff, elongate bristles, termed the brush (br), or brustia.

The epignath (ep) is a lateral prominence borne basally by the outer, or lateral surface, to which the extensor tendon (et), bearing the muscles which open the mandible are attached. At the base of the gnathal edge of the mandible is the gnathite (gn) which bears the flexor tendon (ft), to which are attached the muscles which close the mandible.

The posterior surface of the mandible bears a condyle (co) basally. When the mandible is viewed in position (Fig. 2) it will be seen that the condyle articulates with a cup-shaped structure, the postgenal acetabulum (pgs), sometimes termed the postgenotheca, which is borne by the postgenal process (pp). The ginglymus (g) is a cup-shaped structure borne in an anterior projection, or pivoting point, which is itself borne basally by the anterior surface of the mandible. This process fits into a niche formed at the postero-lateral angle of the clypeus. The ginglymus, or cup-shaped structure within this process, itself receives a projection of the clypeal angle, and thus this process both projects and receives an articulating or pivoting point.

The extensor muscles attached to the extensor tendon exert a pull laterad of the articulating points, causing the mandible to open; while the flexor muscles attached to the flexor tendon exert a pull mesad of the articulating points and cause the mandible to close. The large size of the flexor tendon and the large muscles attached to it, adapt the insect mandible for the powerful crushing action of the closing mandible, whereas for the lesser task of merely opening the mandible a smaller tendon, with small muscle attachments suffices.

Maxilla: The basal segment of the maxilla (Fig. 2) is the cardo (c). This is divided by the cardinal suture into a basicardo (bc) and a disticardo (dc). The basicardo bears a saddle-shaped articulating process proximally, which is composed of an internal cardinal process (cp) and an external epicardo (ec). To the internal cardinal process, a cardinal tendon (ct) is attached. When the muscles attached to this tendon contract, it causes the "saddle", formed by the internal cardinal process and the external epicardo, to ride, or pivot, over a niched ridge (pop) beneath it (or actually dorsal to it.)

Ventrad of the cardo is the maxillary stipes (st). Lying next to the stipes mesally, and separated from it by the parastipital suture (psts), is the parastipes (pst). The parastipital suture is the external manifestation of an internal ridge, or endostipes, to which the flexor muscles of the maxilla are attached.

Laterad of the stipes, lies the palpifer (plf), a faintly demarked area which bears the five-segmented maxillary palpus (mp). Distally the stipes bears two lobes, a mesal lacinia (la) and an outer galea (ga). The lacinia bears a lacinial fringe (lf) along its inner margin and two tooth-like processes termed the lacinio-dentes (ld) at its apex, while just proximad of the laciniodentes is a moveable, spine-like appendage called the midappendix (map). The galea is composed of two segments, a basigalea (bg) and a distigalea (dg), the latter partly concealing the lacinia.

Labium: The labium, or under lip, is divided into a moveable, distal prelabium and a basal postlabium. The postlabium is a well sclerotized area composed of a distal mentum (mn) and a proximal submentum (smn), which is faintly, if at all, demarked from the mentum before it. The proximal angles of the submentum are closely associated with the ventral ends of the postocciput, and in this connection the latter is sometimes termed the trophifer.

The mentum is separated from the prelabium by the labial suture (lbs). The basal segments of the prelabium is composed of the labial stipites (lst) while laterad of the stipites are the palpigers (plg), which bear the three segmented labial palpi (lp). Distally the labial stipites bear the mesal, lance-shaped glossae and the outer, fleshy paraglossae.

Hypopharynx: Fig. 8 represents a lateral view of the hypopharynx. It is composed of a distal region, or distilingua (dl), and a basal region, or basilingua (bl). The distal lobe of the hypopharynix is strengthened on each side by the distilingual sclerites (dls), each of which sends a narrow arm proximally to the opening of the salivary duct (sld), while the basal lobe is strengthened on each side by the presence of the basilingual sclerites (bls). The basilingual sclerite, which is a single, continuous sclerite in the roach as shown by Crampton (1925), is separated in the species under consideration, into a relatively large basal sclerite and a small, narrow distal sclerite, the latter demarking the distilingua from the basilingua. A narrow V-shaped sclerite (vs) borders the mouth opening anteriorly, and its arms continue internally to form a pair of tendons (t) for muscle attachment (Fig. 7).

According to Snodgrass the cavity in which the hypopharynx lies is the preoral cavity (prc). That portion of the cavity between the hypopharynx and the epipharyngeal region is known as the food meatus (fm), while posteriorly between the hypopharynx and the inner surface of the labium, lies the salivary meatus (sm). The proximal region of the food meatus is termed the cibarium (cb) and leads into the true mouth (mth), which in turn leads into the pharynx region (phy) of the gut. The salivary meatus contains in its proximal portion, a small chitinized region termed the salivarium (slv) into which the salivary duct empties.

Tentorium: Fig. 11 is a posterior view of the head capsule to show the tentorium. Invaginations from the anterior tentorial pits (atp) mentioned above, extend posteriorly to form the anterior arms (at) of the tentorium, while invaginations from the posterior tentorial pits (ptp) extend antero-mesally to form the posterior arms (pt). Where the fused posterior arms unite with the fused anterior arms, the corporotentorium (cpt), or ententorium is formed. A niche, or neuroforamen (nf), found anterior of the ententorium, permits the circumoesophageal connectives to pass through from the brain to the suboesophageal ganglion. A furca-like invagination (tp) in the posterior portion of the corporotentorium where the posterior arms unite, probably serves to give additional strength to the tentorium. No dorsal arms of the tentorium are present.

THE THORAX

Neck Region: Although the neck region, or cervix (cv) is here taken up with the thorax, it should be remembered, as Snodgrass, Crampton and others have suggested, that the neck is probably derived from portions of both the labial and prothoracic segments. As is seen in Fig. 6, the greater part of the cervix consists of the cervical membrane (cm) which bears on each side a lateral cervical sclerite (lc). The anterior portion of each lateral cervicale is differentiated into a knob-like cephaliger (cph) which articulates with the occipital condyle of the head, while the posterior portion articulates with a membranous fold just anterior to the episternum (es).

PROTHORAX

Pronotum: The pronotum (pn), seen in Fig. 22, in dorsolateral view, is a saddle-shaped structure which covers the prothorax dorsally and laterally. The upper, dorsal surface is termed the disc (dsc), while the lateral portions are called the lateral lobes (ll). Each lateral lobe has overgrown most of the episternum (es), and the epimeron (ep), but while it has fused with the greater portion of the latter, it has fused only marginally with the episternum. Dorsally, the rounded, posterior portion of the disc partially covers the scutum of the mesothorax. The surface of the pronotum is smooth, but each lateral lobe contains two pronotal sutures, or sulci (su), the anterior of which is continued into the region of the disc.

Propleuron: Only a small, ventral portion of the pleuron is visible just below the rounded, marginal edge of the lateral lobe of the pronotum. It is demarked by the pleural suture (pls) into an anterior episternum (es), and a posterior epimeron (ep). A narrow portion of both the episternum and epimeron continues downward along the pleural suture to form a pleural articulation (a) for the coxa (cx).

If we were to tear away the lateral lobe of the pronotum from the pleuron, we would find a thin, sclerotic continuation of the episternum, while the major portion of the epimeron has become fused with the pronotum. A narrow, thick sclerotization of the epimeron would be found, however, to continue upward along the furrow formed by the pleural suture. The extent of these areas beneath the lateral lobe of the pronotum is shown in Fig. 22, by broken lines. The above substantiates the view of Crampton and Duporte that in the Orthoptera the pronotum has overgrown the pleuron, rather than that the pronotum has forced out the pleuron as some investigators would have us believe.

The region extending downward from the episternum (Fig. 13) anterior to the coxa and the trochantin (tn), and united ventrally with the sternum, is the precoxal bridge, or precoxale (pcx), while the narrow slcerite behind the coxa which unites ventrally with the sternum and dorsally with the peritreme (ptr) of the first thoracic spiracle, is the postcoxal bridge, or postcoxale (pocx).

The trochantin (tn) is a small sclerite, forming a point of articulation for the leg (b), between the precoxale and the coxa.

Fore Leg: The foreleg is shown in Fig. 17, while its articulation with the pleuron can best be seen in Fig.

22. The proximal leg segment, or coxa (cx), articulates with the pleural leg process (plp) at a and with the trochantin at b. (Fig. 13). A coxal spine (cxsp) is borne by the coxa just beneath the pleural articulation. The meron (mr) is represented by a small area. A more detailed discussion of the morphology of the coxa will be taken up under the discussion of the hind leg.

The coxa is followed by the trochanter (tr), with which it articulates at points d and d^1 (Fig. 22). The trochanter is firmly joined to the femur (fm), which is a comparatively stout segment, slightly grooved beneath, the anterior marginal edge of the groove being armed with a number of spines.

The tibia (ti) which follows the femur is almost square in cross-section and each margin is well armed with spurs, which are moveable processes, in contradistinction to the spines of the femur which are immoveable. The proximal portion of the tibia is somewhat flatter and considerably broader than the remainder of the segment, and contains the so called ear, or auditory organ, of the katydid. The external structure of the auditory organ is shown enlarged in Fig. 21. It consists of an oval cavity on each side of the tibial segment, while the surface of the cavity is composed of a membrane containing a thin, elongate-oval sclerite. The internal surface of each area on opposite sides of the tibia become approximated and these structures act like drums to receive vibrations which are transmitted to chordotonal sensillae within the tibia.

The four-segmented tarsus (ta) is almost identical in the fore-, and mid-, and hindlegs, and the descriptions which follow may serve for all of them. The segmental subdivisions of the tarsus may be termed the tarsomeres (tsm), and are best seen in Fig. 19 of the hind leg. The basal tarsomere, sometimes distinguished as the basitarsus (bts) is sub-equal in length to the fourth tarsomere, or distitarsus (dts). The ventral surface of the basitarsus consists of a proximal, bilobed, pad-like structure, pr pulvillus, followed by a single, distal pulvillus, and therefore it is not at all unlikely that the apparent basitarsus consists of two fused tarsomeres. The second tarsomere is the smallest, while the third tarsomere is distinctly bilobed and broader than the others. Both pear pulvilli. The fourth tarsomere, or distitarsus, is cylindrical and lacks pulvilli.

The claws, or ungues (ung), are borne by a distinct segment, which is homologous with the cactylopodite of the crustacean limb. The term pretarsus has been used to designate this segment in insects, but this term is decidedly inaccurate since it implies a segment lying basad of the true tarsus, rather than distad of it. Even the term dactylopodite would be preferable to pretarsus, but this former term is cubersome and properly implies the distal segment of a crustacean limb. Although a concise, descriptive term is desireable, there is no gain in sacrificing clarity for brevity. Therefore it is suggested that the term posttarsus be used to designate this distal segment, since such a term is both accurate and descriptive, and not unwieldly.

An enlarged view of the posttarsus (psta) is seen in ventral view in Fig. 20. The posttarsus bears a pair of lateral claws, or ungues. Each claw articulates dorsally to a median process at the apical end of the distitarsus, termed the unguifer (unf), shown in Fig. 19. On the ventral surface of the posttarsus is a median plate, termed the unguitractor (utr), which lies in part beneath the distoventral sclerotization of the distitarsus. To its proximal end is attached the tendon-like apodeme called the retractor of the claws (t), on which according to Snodgrass, is inserted the depressor muscle of the posttarsus.

Prosternum: A ventral view of the thorax (Fig. 13) shows the greater part of the prosternum to consist of the sternellum (sl), containing the furcal pits (fp) laterally, which invaginate to give rise to the furca, internal processes serving for muscle attachment, while on the posterior portion is borne the spinal pit (sp), which invaginates to form the spina, which likewise serves for muscle attachment. The term sternellum is here used to designate the combined furcasternum and spinasternum, as used by Crampton, although it should be noted that Snodgrass uses the term sternellum as synonymous with furcasternum alone.

The basisternum (bs), is reduced to a small area between the ventral extremities of the precoxal bridges.

MESOTHORAX

Although the mesothorax is somewhat smaller than the metathorax, and is functionally less active, since neither leaping legs nor active flight organs are present, the parts of the mesothorax exhibit a complexity almost equal to that of the metathorax.

Mesonotum: In the anterior region of the mesonotum is a narrow, marginal region termed the pretergite (pt_1). The pretergite is separated from the prescutum (psc_2) immediately behind by the antecostal suture (acs) representing the true intersegmental boundary, which gives rise internally to a pair of small inflections, or lobes, termed the first phragma (ph_1), which serve for the attachment of the dorsal, longitudinal muscles. The prescutum of Snodgrass, is separated by the prescutal suture (pscs) from the large scutal area, or scutum (sc) which follows. The scutum contains a pair of secondary sutures (s), each of which bears internally a lobe-like inflection, which may be termed the interphragma (iph). The posterior region of this tergal plate is occupied by the scutellum (scl), which is flanked on either side by a depressed area called the parascutellum ($pscl_2$) by Crampton. It should be noted, however, that these parascutellar areas actually represent a posterior portion of the scutum. The posterior margin of the scutellum folds under itself to form a reduplication (re).

Along the side of the mesonotum, are found several lateral projections, some of which are involved in the movements of flight and in the stridulating movements. The anterior of these projections is the prealare (pa_2) which is formed from both pretergite and prescutum, while behind this projection lies the suralare (sur_2) which juts out toward the neck of the first axillary ($1ax_2$) and aids in the anterior articulation of the wing. Following the suralare is the anterior notal wing process (anp_2) which abuts against the body of the first axillary, while the posterior notal wing process (pnp) abuts against the third axillary ($3ax_2$). The reduplication (rd) extends laterally into the thickened, membranous axillary cord (axc).

Pteralia: Although the wing articulates with the tergal region of the thorax by a membranous, basal area, there are present in this area a number of articular sclerites which are collectively termed the pteralia. (Fig. 10) The first of these articular sclerites known as the first axillary ($1\,ax_2$) articulates mesally with the anterior notal wing process and suralare, and articulates laterally with the second axillary ($2ax_2$), while an anterior neck-like projection of the first axillary abuts against the base of the subcostal vein (Sc). The second axillary abuts against the common base of the radial and medial veins (R and M) anteriorly, while posteriorly it articulates with an anterior projection of the third axillary ($3ax_2$). The third axillary forms the posterior wing articulation with the posterior notal wing process (pnp_2).

Fore Wing: The forewing is elongate-oval in outline, and is termed the tegmina. Numerous cross-venules (not shown) give it a thickened, leathery texture (Fig. 16).

No distinct costal vein was found to arise from the basal trunk. The subcosta (Sc) whose base abuts against the neck of the first axillary, runs for a short distance and then branches to merge with the numerous venules. The radius (R) continues as a single vein to the apical margin of the wing with no branches, while the media (M) branches into two and then each branch again divides into two subbranches. Cubitus (Cu) branches proximally into two, the anterior branch dividing into a number of sub-branches, while the posterior branch dividing into a number of sub-branches, while the posterior branch runs along the hind margin of the wing and meets the anterior sub-branches. The first anal vein, or vannal vein (1V) of Snodgrass is prominent.

Immediately behind the first vannal vein is the vannal fold (vf) which divides the tegmina into a large, anterior remigial region (rm) and a relatively small, posterior vannal region (vn) which folds over the tergum of the thorax.

When the tegmina are folded in place, their color and position of the veins might readily lead to their being mistaken for the color and venation of a leaf.

Stridulating Mechanism: The vannal region of the forewings of the male katydid, which bears the stridulating mechanism, is shown in Fig. The vannus of the left wing almost invariably folds over the vannus of the right wing. Sub-marginally, the right vannus bears a dorsal rasp (r), or knife-edged sclerotization. Laterad, or actually anterior, of this rasp, the surface of the wing contains a concave area which acts as a resonating chamber (rc). The vannus of the left wing bears a rasping vein (rv), which is seen in Fig. to bear a file-like chitinization ventrally, which may be termed the file (f). As the forewings are expanded and brought back into place, the rasp (r) on the dorsal surface of the right wing moves along the file (f) on the ventral surface of the left wing, producing the stridulation which is amplified and resonated by the resonating chamber (rc) located in the right wing.

Alaria: Fig. 9 shows the ventral articulation of the wing base with the pleuron. There are usually present in this area a number of small sclerites which serve for the insertion of important wing muscles, termed the alaria by Crampton. These sclerites are the epipleurites of Snodgrass.

Anterior of the pleural wing process (pwp) is the basalare (ba_2), while above the pleural wing process is the intralare ($2ax_2$) of Crampton which represents the ventral sclerotization of the second axillary. This latter sclerite pivots upon the pleural wing process in the movement of the tegmina. No subalare sclerite is present in the mesothorax.

Mesopleuron: The major portion of the pleuron is occupied by the episternum (es_2) and the epimeron (ep_2) which are separated by the pleural suture (pls_2). The episternum and the epimeron continue along the pleural suture dorsally to give rise to the pleural wing process (pup_2), while their continuation along the pleural suture ventrally forms the pleural leg process (plp_2).

The anterior, ventral portion of the episternum joins the narrow precoxale (pcx_2), the latter joining with the basisternum ventrally. (Fig. 13).

Anterior to the episternum, in the intersegmental membranous area, is a large cavity which is partly covered by the pronotum. (Fig. 22). At the lower anterior margin of this large cavity is a much smaller spiracular opening. These two openings together constitute the double, first thoracic spiracle (spr_2) which properly belongs to the mesothorax. The larger of these openings sends off a large tracheal branch into the foreleg, while the smaller of these openings sends off a small tracheal branch into the body cavity. This double spiracle is located in a sclerotized area termed the peritreme (ptr).

Snodgrass has shown that the first thoracic spiracle in Dissosteira has a corresponding double tracheation, and therefore gives the appearance outwardly of an apparent double opening. Here in the katydid, the posterior of these openings has become greatly developed and specialized into an "accoustic" trachea with its own separate opening, so that the apparent double spiracular opening of Dissosteira has become in actuality a double opening in Amblycorypha.

Middle Leg: The mesothoracic leg is slightly larger than the foreleg, and except for the absence of an auditory organ, is similar to the foreleg (Fig. 18).

No coxal spine, however, is present on the coxa (cx_2) of the middle leg and the mron (mr_2) is somewhat more developed than that of the foreleg. The coxa articulates with the short trochanter (tr_2) which latter is joined to the femur (fm_2). The femur is grooved beneath and the outer edge of the groove is armed with spines. Following the femur, and slightly longer than it, is the tibia (ti_2). The tibia is square in cross-section and each of its four edges is armed with spurs. The four-segmented tarsus (ta_2) and the posttarsus (psta) are almost identical with those of the foreleg.

Mesosternum: The greater portion of the sternal sclerotization is occupied by the basisternum (bst_2). The basisternum is considerably depressed medially, the lateral edges being raised above the surrounding membranous area, while its posterior lobes jut back toward the metasternum. Lying below the plane of the basisternum, and at an angle to it, is the sternellum (sl_2) which is the furcasternum and spinasternum combined. The sternellum bears the furcal pits (fp_2), each of which gives rise to an internal furca, or apophysis, and the spinal pit (sp_2) which invaginates internally into a pair of narrow lateral arms and a pair of short, posterior, horn-like arms, collectively making up the spina.

METATHORAX

Correlated with the presence of large jumping legs and active organs of flight, the metathorax is the largest and most highly developed of the thoracic segments.

Metanotum: The narrow pretergite of the metanotum, actually belongs to the notum of the preceding segment and enters into the formation of the postnotum, or postscutellum of the mesothorax when the latter is well developed. In the membranous area anterior to the pretergite are two small sclerites (v) which may possibly represent vestiges of the postscutellum. The pretergite is separated by an antecostal suture (acs_3) from the prescutum (psc_3) which follows it. The antecostal suture, as in the preceding mesothoracic segment, gives rise to a pair of inflections, or lobes, termed the second phragma (ph_2) which serves for muscle attachment. Behind the prescutal suture ($pscs_3$) lies the large scutum (sc_3). A transverse membranous area (tm) extends across the scutum, and there is present internally, at each end of the membranous area a lobe, or interphragma (iph_3), which serves for muscle attachment. The presence of both the transverse membrane and the interphragma, would permit an arching and depressing action of the notal plate and this action may possibly play a role in the movement of the hind wings.

Behind this transverse membrane, medially, lies the scutellum (sl_3) which is flanked on either side by a depressed area, the parascutellune ($pscl_3$), which latter region is a part of the scutum. The posterior region of the notal plate folds under itself to give rise to the reduplication (rd). The reduplication is separated by a narrow membranous area from the postnotum, or postscutellune (psl_3), the posterior inflection of which gives rise to the third phragma (ph_3).

There are present in the metanotum, a number of lateral projections as is the case in the mesonotum. There are the prealare (pa_3), the suralare (sur_3), the anterior notal wing process (anp_3) and the posterior notal wing process (pnp_3), whose functions are similar to those described for the mesothorax.

Pteralia: The first axillary ($1ax_3$) articulates with the suralare (sur_3) and the anterior notal wing process (anp_3) mesally, and with the second axillary $2ax_3$) laterally, while an anterior, neck-like projection of the first axillary abuts against the base of the subcosta (Sc). The second axillary merges with the common base of the radius (R) and media (M) anteriorly, while posteriorly it articulates with the third axillary ($3ax_3$). The latter articulates with the fourth axillary ($4ax_3$) which probably represents a detached portion of the posterior notal wing process (pnp_3) and in this case the fourth axillary articulates with the posterior notal wing process.

Hind Wing: The hind wing (Fig. 15) is the active flight organ of the katydid. It is divided by the vannal fold (vf), according to Snodgrass, into an anterior remigial region (rm) and a posterior vannal region (vn). A number of secondary folds (sf) are present in the remigium. The tip of the hind wing, protruding from behind the gegmina, contains numerous venules which give it a tegmina-like texture. The vannal region is a thin membranous region, and it likewise contains a secondary fold (not shown) between each vannal vein which enables it to fold like a fan.

The veins of the hind wing are derived from a common V-shaped trunk, with its apex pointing toward the tip of the wing. The first vein arising from this trunk is the concave subcosta (Sc). This is followed by the convex radius (R) which branches twice near its distal extremity. Media (M) branches twice proximally; the anterior branch divides into a number of sub-branches, while the posterior branch of media divides into two sub-branches and the posterior of these two sub-branches fuses with the first branch of cubitus. Cubitus (Cu) arises from the apex of the V-shaped trunk and almost immediately divides into two branches. Behind the cubitus there is present the postcubitus (Pcu) of Snodgrass, which is the first anal vein of Comstock. Following it are the vannal veins (V) of Snodgrass or anal veins of other authors, which arise as convex veins but become concave halfway toward the margin of the wing.

Alaria: There are two basalar sclerites (ba_3) present at the ventral base of the wing. The anterior of these is joined to the episternum (es_3) and indicates their probable origin as detached portions of the pleuron. Above the pleural wing process (pup) is the intralare ($2ax_3$) or the ventral sclerotization of the second axillary, which serves as a pivoting structure for the wing. Posterior to the pleural wing process there is present an elongate, subalare sclerite (sa_3). It is not definitely known whether the subalare is likewise of a pleural origin, as Snodgrass claims, or whether it arises as an independant sclerotization between the epimeron and the wing base.

Metapheuron: Along the enlarged size of the metathorax we find that the metapleuron is larger than that of the mesopleuron. The episternum (es_3) is separated by the pleural suture (pls_3) from the epimeron (ep_3), which is divided into a broad upper anepimeron (aep_3) and a lower katepimeron (kep_3). A dorsal continuation of the episternum and epimeron along the pleural suture gives rise to the pleural wing process (pwp_3), while a ventral continuation of the same sclerites along the pleural suture forms the pleural leg process (plp_3). The second thoracic spiracle (spr_3) has migrated forward so that it is closely associated with the epimeron of the mesothoracic segment. Both precoxal and postcoxal bridges are lacking. The trochantin (tn_3) is similar to that of the preceding segment.

Hind Leg: According to Snodgrass the proximal end of the coxa (Fig. 23, cx_3) is girdled by a submarginal basicostal suture (bcs), which forms internally a ridge and sets off a marginal region, or basicoxite (bcx). The coxal suture (cxs) falls in line with the pleural suture, dividing the coxa into two parts. The coxal suture likewise divides the basicoxite into a prearticular portion and a postarticular portion. The postarticular portion is termed the <u>meron</u> (mr_3) and the suture which sets it off is a continuation of the basicostal suture. The meron is best developed in the hind leg. The coxa articulates with the pleural leg process at (<u>a</u>) and with the trochantin at (<u>b</u>), while the articular membrane which surrounds its base is termed the coxal corium (cxc).

The <u>trochanter</u> (tr_3) which follows the coxa is reduced to a narrow annualar sclerite, barely visible from the outer view. The <u>femur</u> (fe_3) is broadly developed at its proximal portion and contains the muscles used in jumping. The under surface is grooved and the inner edge is armed with spines. The tibia (ti_3) is similar to that of the preceding segment and is heavily armed with spines on all four of its margins. The <u>tarsus</u> (ta_3) and <u>posttarsus</u> (pta_3) has been described for the prothoracic leg.

<u>Metasternum</u>: The <u>basisternum</u> (bst_3) is larger than that of the preceding segment and the posterior lobes are rounded, while an anterior portion has become sclerotized to form the <u>presternum</u> (pst_3). The <u>furcasternum</u> (fst_3) which follows contains a common <u>furcal</u> <u>pit</u> (fp_3) which gives rise to the furcal invagination. Internally this common furcal pit branches shortly, and each branch in turn gives off two sub-branches. According to Snodgrass no spinasternum is ever present in the metathoracic seg-

ment of insects (although it does occur in the metasternum of Grylloblatta).

ABDOMEN

In the following discussion of the abdomen, the writer has attempted to follow Snodgrass, as closely as possible, in the terminology used to designate the regions of the abdomen and its various parts. Thus, considering the body as a whole, the back and sides above the limb bases is the dorsum and the undersurface between the limb bases is termed the venter, while the region of the limb bases themselves are termed the pleural areas. Each major segmental plate of the dorsum is termed a tergum; each major segmental plate of the venter is termed a sternum, and each major sclerotic plate of the pleural area is termed a pleuron.

If we likewise follow Snodgrass in the opinion that in the generalized segments of most insects the spiracles lie in the sides of the segments above the region of the limb bases, or in the lateral parts of the dorsum, then the groove below the spiracles is the dorso-pleural groove (dpg). The region above the dorso-pleural grooves is the dorsum of the abdomen, while the region beneath the dorso-pleural groove is the combined regions of the abdominal venter and the abdominal pleural areas.

The pregenital region of the abdomen, containing seven segments in the female and eight segments in the male, is discussed collectively under the heading of visceral segments, while the genital and postgenital segments are considered separately under the discussion of the male and female terminalia.

VISCERAL SEGMENTS

A lateral view of the female abdomen is shown in Fig. 22. It comprises by far the greatest volume of the insect body, reaching its greatest cross-section about the region of the third abdominal segment, then gradually tapering posteriorly. With little exception, the structure of the visceral segments is fairly uniform throughout.

Abdominal Terga: The abdominal terga (t_1,t_2, etc.) are the major sclerotized plates of the dorsum of the abdomen. Each segmental area of the dorsum consists of a saddle-shaped tergal plate, followed by a wide, posterior membranous area which is folded beneath the posterior portion of the tergal plate, producing a telescoping effect. In the strictest sense of the word, however, each 'segmental' tergum consists of a narrow, weakly sclerotized pretergal, or acrotergal area, demarked by an antecostal suture, which area actually belongs to the preceding segment. The antecostal suture forms an internal ridge, or antecosta, which serves for muscle attachment.

The pretergite of the first abdominal tergum is well developed and enters into the formation of the postnotum, or postscutellum (psl_3) of the metathoracic segment, as was mentioned in the discussion of the thorax, and the posterior inflection of the postscutellum forms the third phragma serving for muscle attachment. In each succeeding tergal plate, however, the pretergite is ill-defined and merges with the membranous area preceding it.

Spiracles: There are eight pairs of abdominal spiracles (spr) which lie in the thickened membranous region of the dorsum above the dorso-pleural groove. Each spiracular opening lies in a small sclerotic area termed the peritreme (ptr).

Abdominal Sterna and Laterosternites: Beneath the dorso-pleural grooves lie the combined regions of the abdominal venter and the abdominal pleural areas. Since no pleuro-ventral grooves are present, however, there is no way of distinguishing the pleural areas from the venter of the abdomen. The small triangular sclerites, immediately beneath the dorso-pleural groove, lie in the pleural region of the abdomen, but since there is no way of telling from this study alone whether these are derivatives of the primitive bases of abdominal appendages, secondary sclerotizations, or lateral subdivisions of the definitive pleurosterna, they are noncommitally termed laterosternites (lst). These laterosternites, lying in a thickened membranous region are present on the first seven abdominal segments.

Lying medially in this pleurosternal region are the major sclerotic plates of the venter. Each of the first seven abdominal segments of the venter consists of an anterior sternal plate, or sternum (st_1, st_2, etc.), followed posteriorly by a membranous area. The anterior margin of each sternal plate is inflected, forming an internal point for muscle attachment. The abdominal sterna gradually shift posteriorly in the female, so that the seventh sternum (st_7) appears to lie beneath the eighth tergum.

Female Terminalia

The eighth and ninth segments of the female abdomen are adapted by structural and appendicular modifications to perform the genital functions, and are referred to as the genital segments, and are followed by the tenth and eleventh segments which are the postgenital segments. The genital and postgenital segments together with their appendages comprise the terminalia (Fig. 26).

The Eighth Segment: The eighth tergum (t_8) differs little from the visceral terga preceding it. The pleural area, however, contains a sclerotized portion which forms the first valvifer (1vlf). The anterior portion of the first valvifer, which has shifted ventrally, bears the long, curved, blade-like structures which are the first, or ventral valvulae (1 vl) of the ovipositor. (The ovipositor of Orthoptera consists of three pairs of valvulae, a first, second and third pair, although in Acrididae and Gryllidae the second pair may be reduced or rudimentary. In other insects which bear an ovipositor, such as Thysanura, Hemiptera and Hymenoptera, there are only two pairs of valvulae and these are the first and second pairs.) The upper, outer margin of the first valvula contains a dorsal groove (dg) which interlocks with the ventral edge of the third, or dorsal valvula (3vl), while the ventral margin of the first valvula is strongly toothed apically. The posterior, or upper portion of the first valvifer bulges and overlaps a basal portion of the dorsal valvula.

The eighth sternum (st_8) forms a triangular, subgenital plate (sgp) which underlies the bases of the first valvulae. Between the ventral bases of the first valvulae and the dorsal surface of the subgenital plate, there is formed a genital chamber (gc).

Fig. 25 shows a ventral view of the female terminalia with the subgenital plate pulled back anteriorly, exposing the genital chamber. The genital chamber is an external pouch, or pocket, formed between the ventral bases of the first valvulae and the dorsal surface of the eighth sternum. The median gonopore (gpr), which is the true external genital opening, is located anteriorly on the floor of the genital chamber, which floor forms the dorsal surface of the subgenital plate. The posterior opening of the genital chamber, which receives the male spermatophore, is termed the vulva (vul). The gonopore is the opening of the median oviduct (odc) (shown by broken lines in Fig. 26) into which the paired, lateral oviducts (odl) discharge. The membranous lips of the gonopore continue posteriorly along the dorsal surface of the subgenital plate, and form a membranous subchamber, within the genital chamber. Located on the roof the genital chamber, between the bases of the ventral valvulae, is the minute spermathecal aperture (spr), which leads through a narrow, spermathecal duct (spd) ihto the sac-like spermatheca (spt) in which the female stores the sperm after copulation.

It should be noted that the eighth sternum, or subgenital plate, and the first volvifers have shifted posteriorly, and appear to be more closely associated with the ninth tergum, than with the eighth tergum to which they actually belong.

The Ninth Segment: The ninth tergum (t_9) is somewhat narrower than the eighth tergum, and its antecostal ridge is strongly developed, particularly along its lateral portions, serving for the attachment of the muscles associated with the ovipositor.

The pleural area of the ninth segment is represented by the reduced, <u>second valvifers</u> (2vlf). The anterior portion of the second valvifer gives rise to the second, or <u>inner valvulae</u> (2vl) of the ovipositor, while the posterior portion of the second valvifers bears the third, or <u>dorsal valvulae</u> (3vl). This relationship of the inner and dorsal valvulae to the second valvifer is not altogether evident outwardly, since the sides of the dorsal valvulae have grown down about the inner valvulae and the latter have been displaced posteriorly. The relationship of the parts of the ovipositor is further obscured in the adult, by the fact that the ventral bases of the inner valvulae have fused with the bases of the dorsal valvulae (Fig.) and the second valvifers have been displaced dorsally by the first valvifers. If careful study is given to the development of the ovipositor in this family, however, the true relationship of the parts of the ovipositor to one another becomes clear, and this has been shown by Walker, Snodgrass and others.

As mentioned above, the bases of the inner valvulae are fused with one another, and are in turn fused with the bases of the dorsal valvulae. The fused bases are strengthened and united by a narrow, transverse sclerotic bar, or <u>anterior intervalvula</u> (avl) shown in Fig. 25. Laterally this bar unites with the dorsal valvulae, and further sends two sclerotic continuations posteriorly along the ventral edges of the inner valvulae, which are termed the rami (ra). Each ramus sends a sclerotic continuation or pons valvulorum (pnvl) anteriorly along the outside of the inner valvulae which unite dorsally and meet a narrow transverse, termed the posterior intervalvula (pvl), at the dorsal base of the inner valvulae. Where the united pons valvulorum meets the posterior intervalvula, there is a pit-like invagination which gives rise to an internal apodeme which serves for muscle attachment. The lateral extremities of the posterior intervalvula unite with the dorsal valvulae.

The dorsal valvulae which enclose the inner valvulae are the broadest blades of the ovipositor. The upper edges are sharply toothed posteriorly, while the ventral edges are smooth and lock with the dorsal grooves of the ventral valvulae.

Briefly the passage of the egg from the female may be summarized as follows. The egg passes down the lateral oviduct (odl) into the median oviduct (ode) and out through the gonopore (gpr). As the egg passes out through the gonopore, into the subgenital chamber, it is fertilized by one of the sperm which are pumped out through the spermathecal aperture (spr). The lips of the gonopore which extend posteriorly, apparently guide the egg between the ventral valves, down which it passes before being inserted into the ground.

It should be noted that the deposition of eggs into the ground is unique among the Phaneropterinae, the edges of leaves and twigs being the usual depository. The following accounts of Hancock is taken from Blatchley (1920 pg. 479).

"When ready to oviposit.....the female curves her abdomen, which is now distended with eggs, forward underneath her body and at the same time seizes the end of the large ovipositor in her mandibles. In this way she directs its point to the desired point in the ground. Then she forces or drills a hole in the earth for the reception of each egg or cluster of eggs."

<u>The Tenth Segment</u>: The <u>tenth tergum</u> (t_{10}) is greatly reduced and narrowed. Medio-dorsally it unites with the eleventh tergum, or epiproct, although a constriction remains at each side to demark its former limits. The antecostal ridge is well developed. The tenth segment lacks appendages and the venter is entirely membranous and reduced.

<u>The Eleventh Segment</u>: The eleventh segment bears the <u>anus</u> (an) posteriorly. Its tergum forms the short, broad, supra-anal plate, or epiproct (eppt), while the ventro-lateral parts of the segment form two membranous lobes, or <u>paraprocts</u> (papt), on each side of the anus.

Below the epiproct, and almost immediately, behind the tenth tergum is the single-segmented <u>cercus</u> (cer), which, though it appears to be borne by the tenth segment, is a recognized appendage of the eleventh segment. At the base of the cercus is a small sclerotized plate, or basi-cercus (bsc).

The Male Terminalia

Contrasted with the female, the male has only a single genital segment, or gonosomite, which is the ninth segment. The eighth segment thus remains a pregenital, or visceral segment and is similar to those segments as described in the female.

The Ninth Segment: Apart from a slight difference in size, the ninth tergum (t_9 differs but little from the preceding visceral segments.

The ninth sternum (st_9) enters into the formation of the male subgenital plate (sgp), which bears a pair of styli (sty) posteriorly (Fig. 23). It is apparent from the presence of the styli, however, that the subgenital plate consists of the gonopod bases, which have shifted from their original pleural position and fused with the definitive sternal plate. The dorsal surface of the subgenital plate is concave and forms a genital chamber (gc) which contains the phallus (phl).

The phallus arises medially on the intrasegmental membrane of the ninth segment which has invaginated inward in the formation of the genital chamber. Fig. 24 shows a dorso-posterior view of the phallus. In its ordinary retracted state the phallus appears to be a short, broad, fleshy lobe within the genital chamber. Closer examination, however, reveals the phallus to consist of a dorsal lobe (dl), a pair of large lateral lobes (ll) and a ventral lobe (vl), which fold together tightly about the posterior opening of the phallus, or phallotreme (phtr). The ventral surface of the dorsal lobe bears a phallic papilla (php) posteriorly, which fits into a phallic notch (phn) on the ventral lobe, enabling the lobes to remain tightly locked together while the phallus is not in use. The phallotreme opens into the endophallic cavity which, in turn, opens anteriorly into the ejaculatory duct through the gonopore. The armature, or modified lobes, usually present on the dorsal surface of the dorsal lobe in the phallic organs of other Tettigoniids, is lacking.

The "flat, toguelike fold that divides the endophallic cavity into a dorsal and ventral compartment" mentioned by Snodgrass (1937, pg. 67) is probably the fold (f) borne by the lateral lobe, which serves to lock the lateral lobes with the lateral edges of the dorsal lobe when the phallus is retracted. The writer was able to view the phallus of a specimen containing a spermatophore, which when removed left the phallus in a protracted state and there was apparently no functional division of the endophallic cavity into two compartments. It should be noted that the phallus is used to form the spermatophore, and is not an intromittent organ.

The Tenth Segment: The tenth tergum (t_{10}) suffers a deduction in size. Dorsally it contains a triangular, median depression. The pleurosternal area of the tenth segment is greatly reduced and is represented by the membranous region above the phallus.

The Eleventh Segment: The eleventh tergum forms the epiproct (eppt) above the anal opening. In the male the epiproct is bent sharply downward. The anus is flanked on each side, and somewhat ventrally by the paraprocts (papt). The eleventh segment bears the cerci (cer), which in the male are curved inward and may possibly have a clasping function. The sclertic area at the base of the cercus is the basicercus (bsc).

BIBLIOGRAPHY

Blatchley, W.S.
1920 Orthoptera of North-Eastern America.
Nature Publishing Company, Indianapolis, 784 pgs., 246 figs.

Comstock, J.H.
1918 The Wings of Insects.
Comstock Publishing Company, Ithaca, New York, 430 pgs., 427 figs.

1940 An Introduction to Entomology, 9th Ed., Revised.
Comstock Publishing Company, Inc., Ithaca, New York, 1064 pgs., 1228 figs.

Crampton, G.C.
1918 The thoracic sclerites of the grasshopper _Discosteira carolina_.
Ann. Ent. Soc. Amer., Vol. 11, 347-366, 1 pl. & 3 figs.

1921 The sclerites of the head, and the mouthparts of certain immature and adult insects.
Ann. Ent. Soc. Amer., Vol. 14, 65-103, 86 figs.

1925 The external anatomy of the head and abdomen of the roach, _Periplaneta americana_.
Psyche, Vol. 32, 195-220, 26 figs.

1926 A comparison of the neck and prothoracic sclerites throughout the orders of insects from the standpoint of phylogeny.
Trans. Amer. Ent. Soc., Vol. 52, 199-248, 120 figs.

1927 The thoracic sclerites and wing bases of the roach _Periplaneta americana_ and the basal structures of the wings of insects.
Psyche, Vol. 34, 59-72, 16 figs.

1929 The terminal abdominal structures of female insects compared throughout the orders from the standpoint of phylogeny.
Jour. N.Y. Ent. Soc., Vol. 37, 453-496, 107 figs.

Crampton, G.C.
1930 The head structures of the Orthopteron Stenopelmatus - a contribution to the study of the external anatomy of Stenopelmatus.
Pan.-Pac. Ent., Vol. 6, 97-108, 15 figs.

1931 A phylogenetic study of the posterior metathoracic and basal abdominal structures of insects with particular reference to the Holometabola.
Jour. N.Y. Ent. Soc., Vol. 39, 323-356, 34 figs.

Duporte, E. Melville
1919 The propleura and the pronotal sulci of the Orthoptera.
Can. Ent., Vol. 51, 147-153, 13 figs.

Eltringham, H.
1933 The Senses of Insects.
Methuen & Co., Ltd, London, 126 pgs., 25 figs.

Forel, Auguste
1908 The Senses of Insects (Trans. by Macleod Yearsley)
Methuen & Co., Ltd, London, 324 pgs., 2 pls.

Gurney, Ashley Buell
1936 The external morphology and phylogenetic position of the woodland cave cricket (Ceuthophilus brevipes Scudder; Orthoptera; Tettigoniidae).
Psyche, Vol. 44, 281-314, 27 figs.

Holway, Richard T.
1935 Preliminary note on the structure of the insect pretarsus and its possible phylogenetic significance.
Psyche, Vol. 42, 1-24, 26 figs.

1937 The comparative morphology of the insect pretarsus.
Unpublished thesis, Massachusetts States College, 117 pgs., 374 figs.

Imms, A.D.
1929 A General Textbook of Entomology.
Methuen & Co. Ltd., 698 pgs., 607 figs.

Martin, J.F.
1916 The thoracic and cervical sclerites of insects.
Ann. Ent. Soc. Amer., Vol. 9, 35-83, 15 figs.

Needham, James G.
1935 Some basic principles of insect wing venation. Psyche, Vol. 43, 113-129.

Newell, Anna Grace
1918 The comparative morphology of the genitalia of insects. Ann. Ent. Soc. Amer., Vol. 11, 109-142, 17 pls.

Snodgrass, R.E.
1929 The thoracic mechanism of a grasshopper and its antecedents. Smiths. Misc. Coll., Vol. 82, No. 2, 111 pgs., 54 figs.

1931 Morphology of the insect abdomen. Part 1. General structure of the abdomen and its appendages. Smiths. Misc. Coll., Vol. 85, No. 6, 128 pgs., 48 figs.

1933 Morphology of the insect abdomen. Part 2. The genital ducts and the ovipositor. Smiths. Misc. Coll., Vol. 89, No. 8, 148 pgs., 48 figs.

1935a The abdominal mechanisms of a grasshopper. Smiths. Misc. Coll., Vol. 94, No. 6, 89 pgs., 41 figs.

1935b Principles of Insect Morphology. McGraw-Hill Book Company, Inc., New York & London, 666 pgs., 319 figs.

1936 Morphology of the insect abdomen. Part 3. The male genitalia (including Arthropods other than insects). Smiths. Misc. Coll., Vol. 95, No. 24, 96 pgs., 29 figs.

1937 The male genitalia of arthopteroid insects. Smiths. Misc. Coll., Vol. 96, No. 5, 107 pgs., 24 figs.

Walker, E.M.
1919 The terminal abdominal structures of arthopteroid insects: a phylogenetic study. Part 1. Ann. Ent. Soc. Amer., Vol. 12, 267-316, 71 figs.

Walker, E.M.
1922 The terminal structures of orthopleroid insects: a phylogenetic study. Part 2. Ann. Ent. Soc. Amer., Vol. 15, 1-79, 106 figs.

1932 Prognathism and hypognathism in insects. Can. Ent., Vol. 44, 223-229, 7 figs.

Wigglesworth, V.B.
c1934 The Principles of Insect Physiology. E.P. Ditton and Company, Inc., New York, 434 pgs., 316 figs.

ABBREVIATIONS

a - pleural leg articulation
aar - antennal articulation area
af - antennifer
an - anus
anp - anterior notal wing process
ap - antennal pivoting process
asc - antennal sclerite
aso - antennal socket
at - anterior tentorial arm
atp - anterior tentorial pit
avl - anterior intervalvula
1 ax - 1st axillary
2 ax - 2nd axillary
3 ax - 3rd axillary
4 ax - 4th axillary
axc - axillary cord

b - trochantinal articulation of coxa
ba - basalare
bc - basicardo
bcer - basicercus
bcs - basicostal suture
bcx - basicoxite
bg - basigalea
bl - basilingua
bls - basilingual sclerites
br - brustia, or brush of mandible
bs - basisternum
bsc - ball of scape
bta - basitarsus

c - cardo
cb - cibarium
cer - cercus
clp - clypeus
cm - cervical membrane
co - condyle
cp - internal cardinal process
cph - cephaliger
cpt - corporotentorium
ct - cardinal tendo
Cu - Cubitus, or cubital vein
cv - cervix
cx - coxa
cxs - coxal suture
cxsp - coxal spine

d,d' - coxo-trochanter articulations
dc - disticardo
dg - distigalea
dgr - dorsal, interlocking groove of ovipositor
dl - distilingua
dlp - dorsal lobe of phallus
dls - distilingual sclerite
dpg - dorso-pleural groove
dsc - disc of pronotum

e - compound eye
ec - epicardo
eg - endograth
ep - epimeron
epg - epigrath
eppt - epiproct
es - episternum
et - extensor tendon

f - file of rasping vein
fem - femur
fm - food meatus
fp - furcal pit
fr - frons
fs - furcasternum
fst - fastigium
ft - flexor tendon

g - ginglymus
ga - galea
gc - genital chamber
ge - gena
gn - gnathite

in - incisor region
iph - interphragma

la - lacinia
lb - labium
lbs - labial suture
lc - lateral cervical
ld - lacinio-dentes
lf - lacinial fringe
ll - lateral lobe of pronotum
llp - lateral lobe of phallus
lp - labial palpus
lr - labrum
ls - laterosternite
lst - labial stipites

M - Media, or medial vein
m - mola
ma - muscle attachment
map - midappendix
mn - mentum
mp - maxillary palpus
mr - meron
mth - mouth

nf - neuroforamen

occ - occipital condyle
ocf - occipital foramen
odc - median oviduct, or oviduct communis
odl - lateral oviduct, or oviduct lateralis

pa - prealare
pap - postoccipital process
papt - paraproct
pcx - precoxale
pdc - pedicel
pga - postgenal acetabulum, or postgenatheca
pge - postgena
pgs - postgenal suture
ph - phragma
phl - phallus
phn - phallic notch
php - phallic papilla
phtr - phallotreme
phy - pharynx
plf - palpifer
plg - palpiger
plp - pleural leg process
pls - pleural suture
pn - pronotum
pnp - posterior notal wing process
pnvl - pons valvulorum
poc - postocciput
pocx - postcoxale
poe - postepipharynx
pos - postoccipital suture
pp - posgenal process
ppd - postpedicel
prc - preoral cavity

pre - preepipharynx
ps - presternum
psc - prescutum
pscl - parascutellum
pscs - prescutal suture
psl - postscutellum, or postnotum
pst - parastipes
psta - posttarsus
psts - parastipital suture
pt - posterior tentorial arm
ptp - posterior tentorial pit
pu - pulvillus
pvl - posterior intervalvula
pwp - pleural wing process

R - Radius, or radial vein
r - rasp
ra - ramus
rc - resonating chamber
rd - reduplication
rm - remigium
rv - rasping vein

S - sternum
Sc - Subcosta, or subcostal vein
sc - scutum
scl - scutellum
scp - scape of antenna
sf - secondary wing fold
sge - subgena
sgp - subgenital plate
sgs - subgenal suture
sl - sternellum
sld - salivary duct
slv - salivarium
sm - salivary meatus
smn - submentum
sp - spinal pit
spr - spermathecal aperture
st - stipes
sty - stylus
su - sulci
sur - suralare

T - tergum
t - tendon
ta - tarsus
te - temporal region
tf - tentorial furca, or pit
to - tormae
ts - temporal suture
tsm - tarsomere

unf - unguifer
ung - ungue, or claw

V - vannal vein
vf - vannal fold
vl - valvula
vlf - valvifer
vlp - ventral lobe of phallus
vn - vannal region, or vannus
vs - V-shaped, surlingual sclerite
vul - vulva
vx - vertex

EXPLANATION OF PLATES

Plate I

Fig. 1 - Anterior view of head
Fig. 2 - Posterior view of head
Fig. 3 - Basal and distal segments of antenna
Fig. 4 - Posterior view of right mandible
Fig. 5 - Undersurface of labrum, showing epipharynx
Fig. 6 - Postero-lateral view of head and cervix
Fig. 7 - Dorsal, or anterior view of hypopharynx
Fig. 8 - Lateral view of mouth cavity

Plate II

Fig. 9 - Ventral view of left wing bases
Fig. 10 - Dorsal view of mesothorax and metathorax, with right wing bases
Fig. 11 - Posterior view of headcapsule, with mouthparts removed, showing tentorium
Fig. 12 - Ventral view of vannal area of left wing of male, showing file of rasping vein
Fig. 13 - Ventral view of thorax
Fig. 14 - Dorsal view of vannal areas of tegmina of male, showing stridulating mechanism

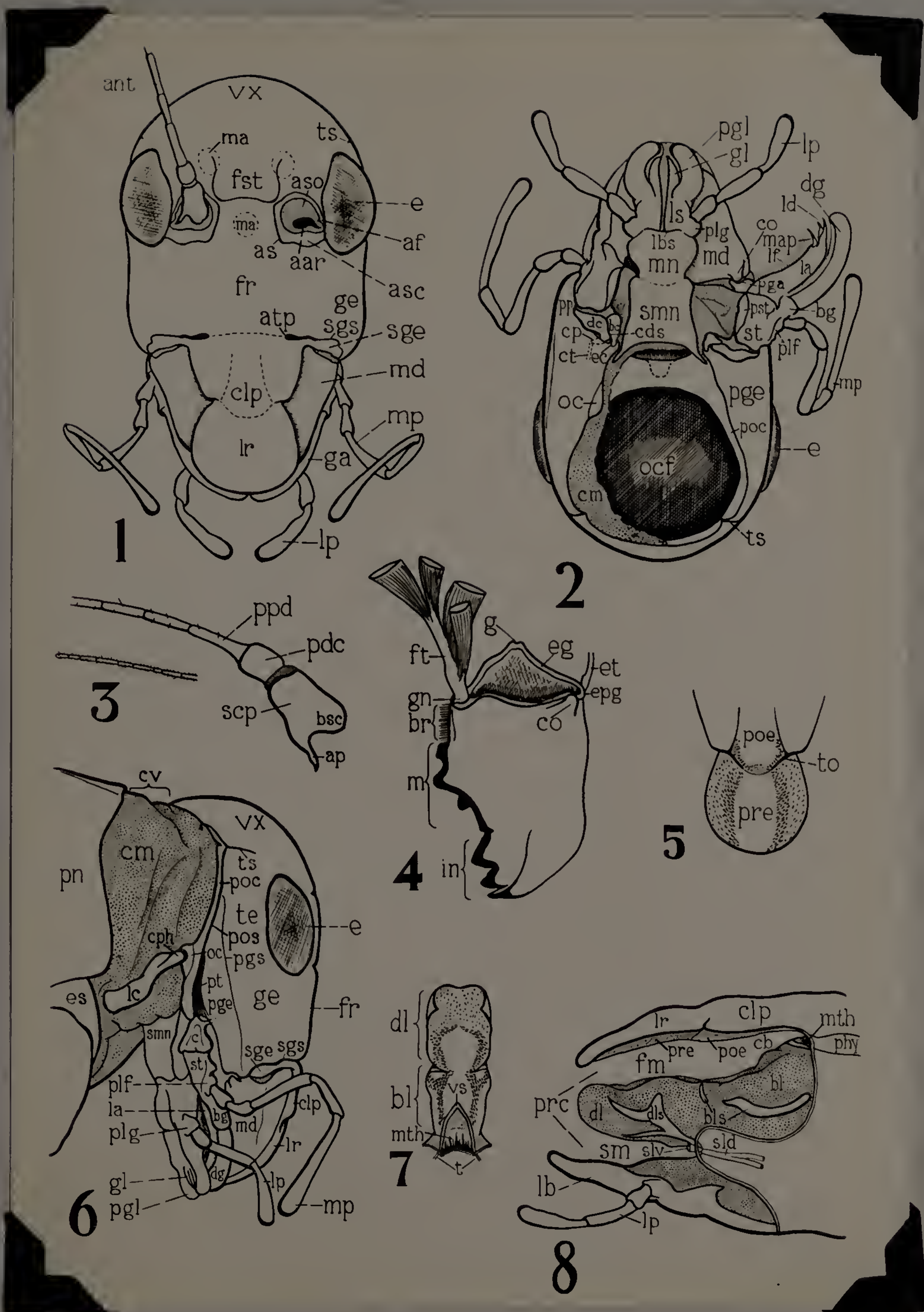
Plate III

Fig. 15 - Hind wing of female
Fig. 16 - Fore wing of female
Fig. 17 - Fore leg
Fig. 18 - Middle leg
Fig. 19 - Hind leg
Fig. 20 - Ventral view of possarsus of hind leg
Fig. 21 - Enlarged view of "ear" of fore leg

Plate IV

Fig. 22 - Lateral view of thorax and abdomen
Fig. 23 - Lateral view of male terminalia
Fig. 24 - Posterior view of male terminalia showing phellus
Fig. 25 - Ventral view of female terminalia, with subgenital plate pulled back
Fig. 26 - Lateral view of ovipositor

PLATE I



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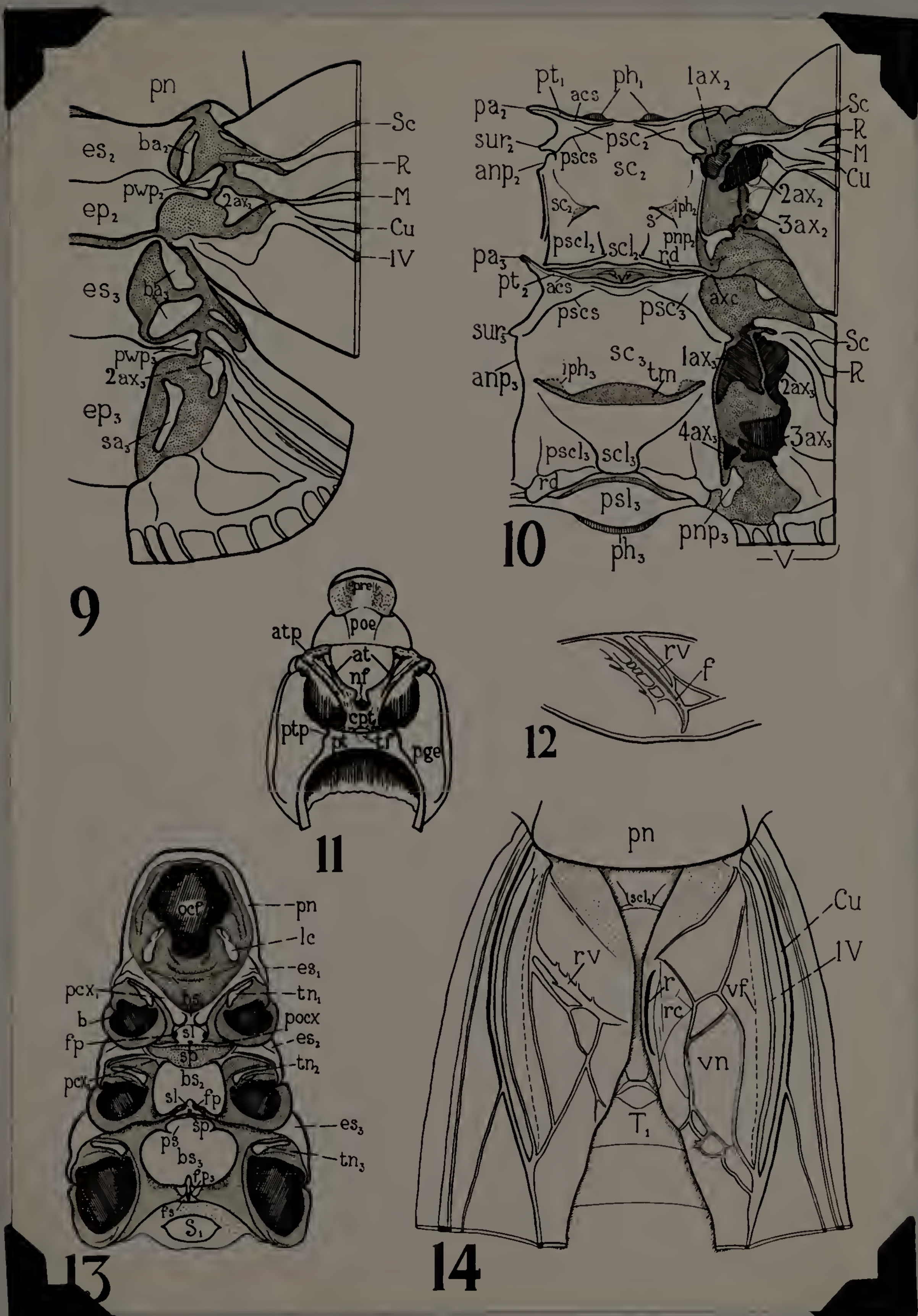

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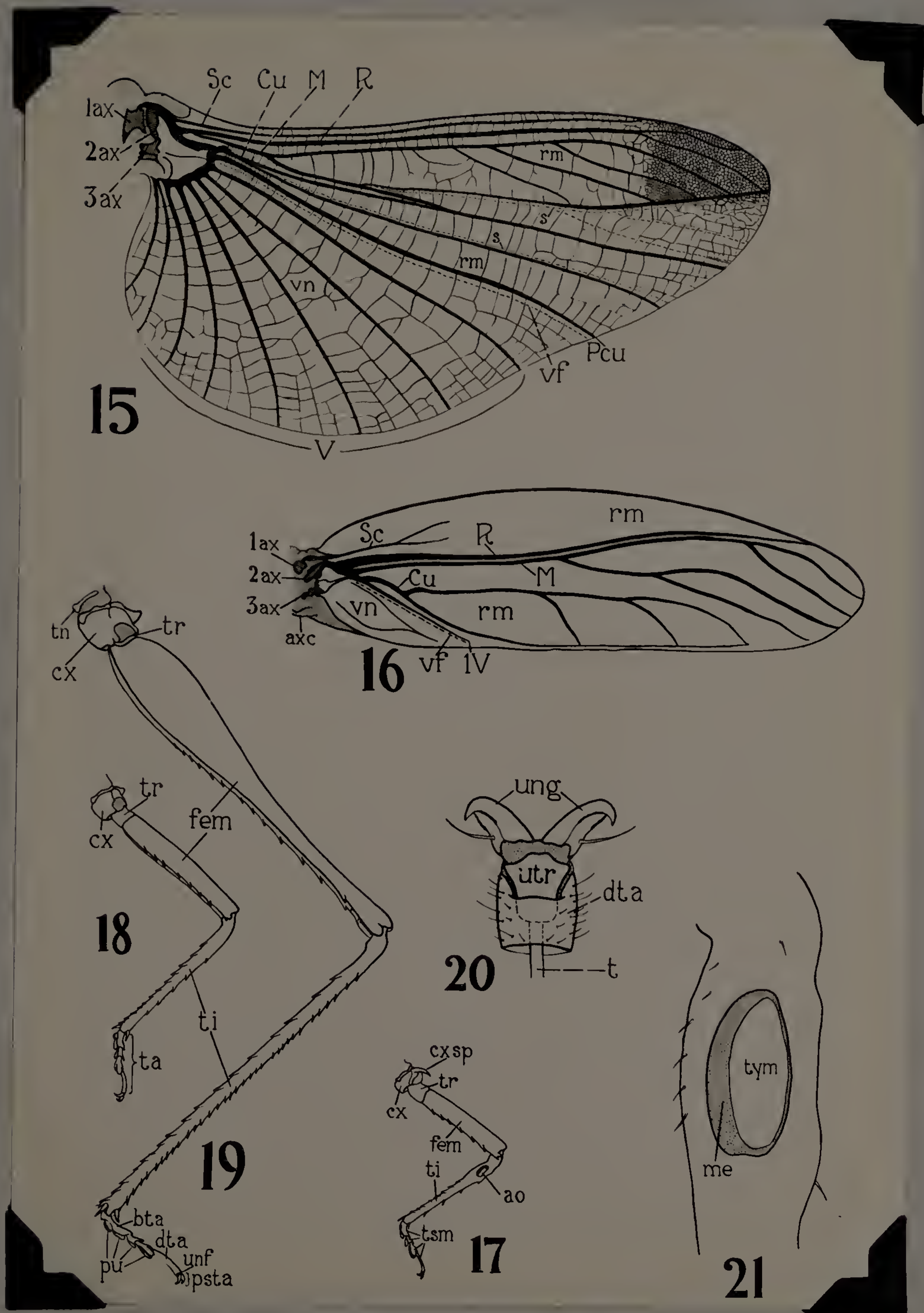

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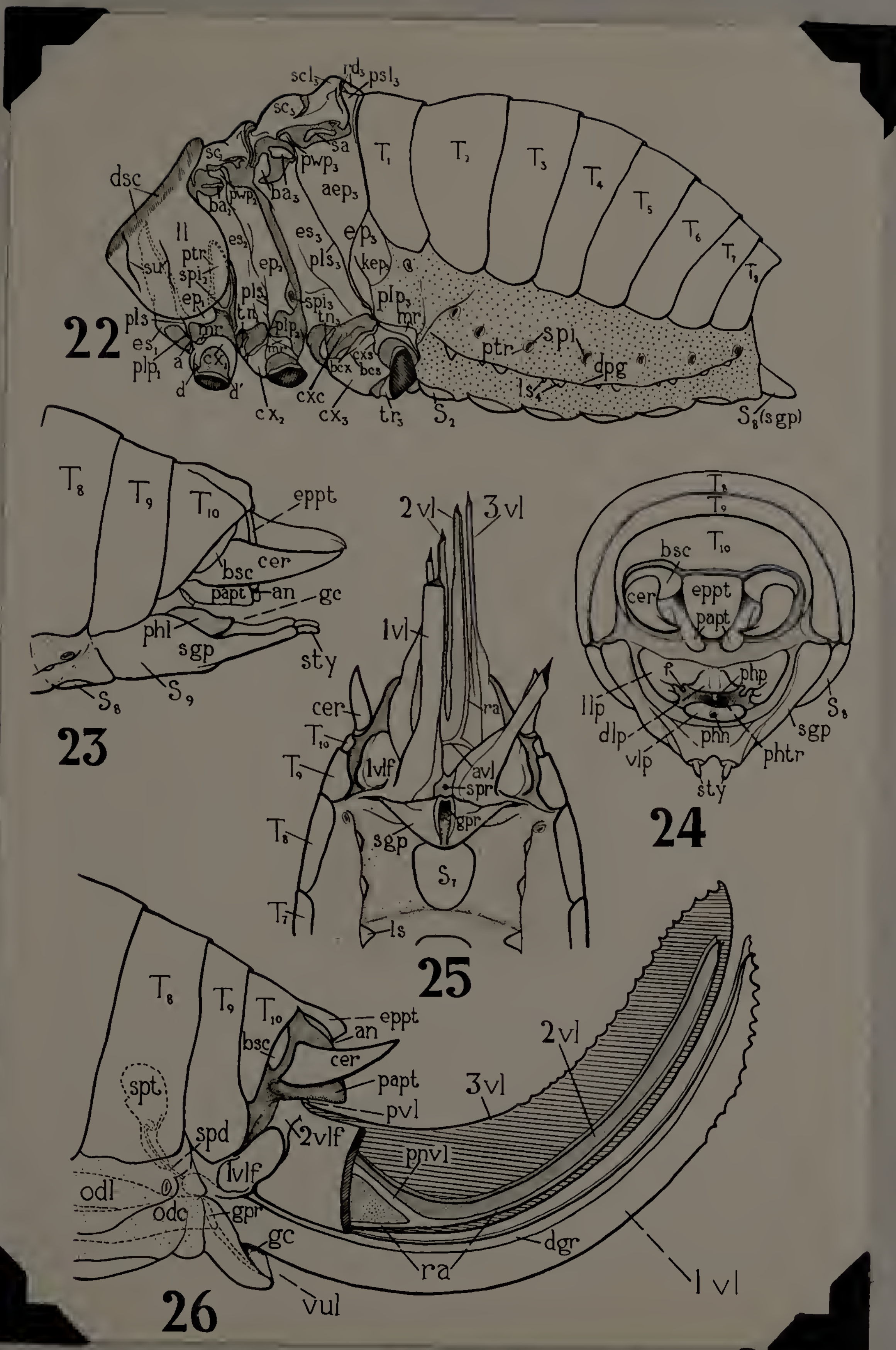
PLATE IV



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